SEQ Regional Desalination Plant Siting Studies

Synthesis Report

Submitted to the
Queensland Water Commission

By
SEQ Healthy Waterways Partnership

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1 Introduction

1.1 Whole-of systems Approach in Planning for Water Needs in SEQ

With a predicted population increase in South East Queensland (SEQ) to 3.7 million people by 2026, the regional focus in relation to water is on adequacy of supply, demand management, water recycling and halting declines in the health of our waterways. The SEQ Healthy Waterways Strategy (released by SEQ Healthy Waterways Partnership) and SEQ Water Strategy (released by Queensland Water Commission), both contribute to ensure the security of water and waterways in SEQ.

Water supply, water quality, waste water treatment, urban use and reuse and healthy waterways are inextricably linked, needing tightly linked strategic planning. The sustainability of our rural sector and industrial growth, as well as achieving good ecosystem health in our waterways are all essential for urban growth. ***Hence planning for water needs to be done in a whole of systems context, embracing the SEQ region overall and embodying natural resource management in the broadest sense and not just water resources in isolation.***

1.2 Ensuring Protection of Moreton Bay

Moreton Bay is characterised by a unique juxtaposition and connectivity of a diverse range of estuarine and marine habitats (Figure 1). A number of representative habitats occur within the Bay, including:

- estuarine intertidal habitats, such as mangrove swamps, tidal flats and rocky shores;
- inshore subtidal communities made up of coral;
- algal/sponge communities; and
- offshore, deep water habitats.

This diversity of habitat types (sheltered estuary versus active systems such as beaches and sandy channels) in close proximity is especially important for migratory species that use the Bay.

Connectivity between the habitats of the Bay operates at various spatial scales. At a broad scale, natural processes of the Bay interact to form a physico-chemical gradient between the Western Bay and the Eastern Bay and offshore areas, with the former exhibiting poor water quality as a result primarily of run-off from land.

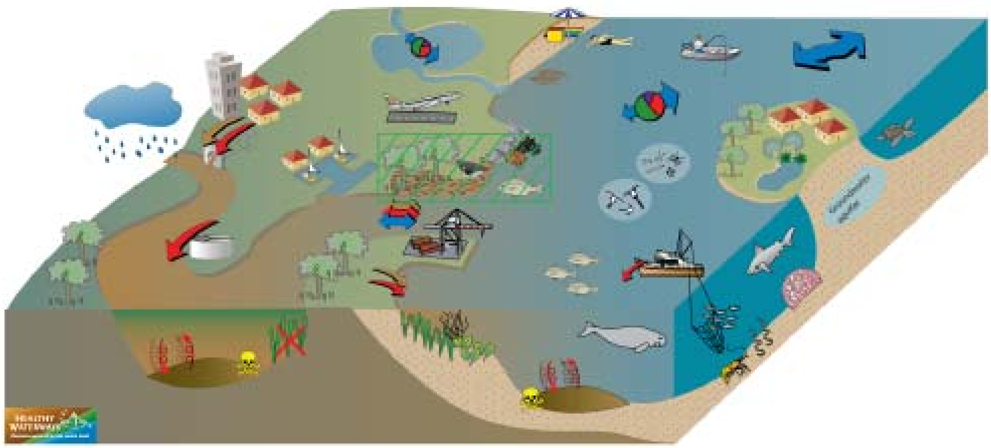

Figure 1. Moreton Bay supports a unique juxtaposition of a number of habitats and exhibits a strong west-east gradient in water quality.

2 Background

The Draft SEQ Water Strategy, released by the Queensland Water Commission (QWC) in March 2008, outlines a plan to supply the region's water requirements for a period of 50 years, while simultaneously ensuring the health of catchments, aquifers and ecosystems. The SEQ WS, together with the SEQ Healthy Waterways Strategy 2007-2012 and the draft SEQ Natural Resource Management Plan 2031, comprises the strategic framework by which the SEQ Healthy Waterways Partnership operates in contributing to the delivery of the SEQ Regional Plan 2005-2026.

As part of SEQ Water Strategy, the QWC has identified the need to consider further desalination facilities as a potential future water source. To ensure that the outcomes of the SEQ Water Strategy take into consideration the resource condition targets (RCTs) outlined in the SEQ Healthy Waterways Strategy, especially in relation to Moreton Bay, the QWC sought the services of the SEQ Healthy Waterways Partnership office to scope the likely impacts of a desalination plant located in the vicinity of the mouth of the Brisbane River, with consideration of alternative discharge points and plant volumes. Such information will be used in the categorisation of the six potential desalination sites identified in the Draft SEQ Water Strategy.

3 Objectives

The objectives of this study were to conduct sufficient modelling and literature review to determine:

- the best location for a brine outfall to service a desalination plant in the vicinity of the mouth of the Brisbane River; and
- the maximum sustainable rate that desalination plant brine can be discharged in the vicinity of the mouth of the Brisbane River.

4 Methodology

4.1 Overall

On behalf of the QWC, the HWP commissioned a joint team of ARUP and BMT WBM to undertake the following scope of works:

- A *literature review* into the possible increased salinity impacts on the Brisbane River and Moreton Bay ecosystems (undertaken by BMT WBM);

- *Modelling* of brine dispersion at five selected discharge locations in the vicinity of the mouth of the Brisbane River and Moreton Bay for five different capacity desalination plants (undertaken by ARUP); and

- *Interpretation* of the modelling results in terms of predicted impacts and the maximum sustainable rate of brine discharge at each of the discharge sites (undertaken by ARUP and BMT WBM).

The overall project management, quality assurance and rigour, synthesis and links to other initiatives were conducted by the SEQ Healthy Waterways Partnership, through mainly its Scientific Expert Panel and Modelling Advisory Panel.

In response to comments of the SEQ Healthy Waterways Partnership Modelling Advisory Panel, additional analysis was undertaken with regard to the predicted extent of environmentally sensitive areas impacted by elevated salinities. A further literature review was also undertaken in relation to the tendency of haloclines to occur in association with hypersaline conditions and the corresponding implications to ecosystem values.

The results of the work (refer to Appendix 1: ARUP Final Report) conducted by ARUP and BMT WBM provided the basis for this ***Synthesis Report***.

It should be noted that the study implemented a conservative approach, whereby the brine discharge was modelled as a point source discharge. The options of variable feed water quality and diffusers were not considered at all.

4.2 Estimating the extent of influence of Advanced Water Treatment Plants concentrate discharges

Additional modelling of reverse osmosis concentrate from the Advanced Water Treatment Plants (AWTP) in the Brisbane River lower estuary was also conducted to estimate their extent of influence on the brine discharge locations (undertaken by ARUP).

A key input in the selection of locations for a brine discharge, and for intake structures, was the presence of AWTPs and their associated discharges in the lower estuary. From an intake perspective, the location of an intake structure would optimally avoid any influence from the AWTP concentrate discharges and therefore reduce the risk of contaminants entering the desalination plant.

From a discharge perspective, the optimal location of a brine discharge outfall would also avoid any plume from such AWTP concentrate discharges. Avoiding plume interaction reduces the risk of further stressing the receiving waters in the mouth of the Brisbane River from potential accumulation of contaminants generated from reverse osmosis processes. Such contaminants may include iron, anti-scalants and biocides.

Two AWTPs using reverse osmosis technology have commenced operation in the Brisbane River lower estuary as part of the Western Corridor Recycled Water Project. Details of discharge characteristics for the AWTPs were provided by QWC. With the AWTPs operating at design capacity, the following flow rates of AWTP concentrate were assumed:

- Luggage Point: 12ML/d
- Gibson Island: 18ML/d

An arbitrary discharge tracer concentration of 100mg/L was assumed for all the plants. Using this conservative tracer, dispersion modelling was then undertaken to evaluate the potential extent of influence from these AWTP concentrate discharges.

The climatic period used for this scenario (and all subsequent brine dispersion model scenarios) was the 1999-2000 fiscal year as adopted for the scenarios used in the SEQ Healthy Water Strategy.

The results for the AWTP dispersion scenarios are provided in Figure 2 for December 1999 and April 2000. Although predicted concentrations are low, the plume from the AWTPs extends to the north of the Brisbane River along the shores of Bramble Bay to the north. Concentrations equal to or exceeding 0.25% of the original discharge concentration extend from the top of the Fisherman Islands along the coast to the mouth of the Pine River.

These results were used as input into the subsequent consideration of the brine discharge outfalls. Although the AWTP plants have negligible salinity impacts, avoidance of any AWTP concentrate plume was one of the considerations in the optimal location of a brine discharge. As noted above, this reduces the risk of further stressing the receiving waters through the potential accumulation of contaminants and salinity changes.

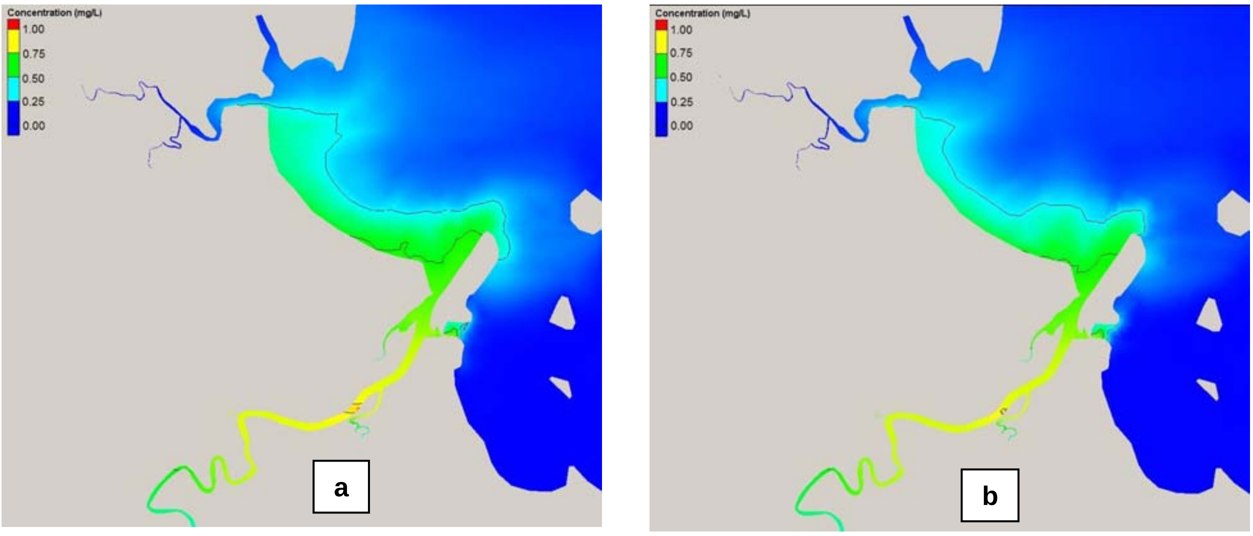

Figure 2. Dispersion modelling results indicating predicted AWTP plumes in a) December 1999 (wet) and b) April 2000 (dry).

4.3 Estimating Exposure to Salinity Changes: Dispersion Modelling of Brine Discharges

In consultation with QWC, five outfall sites were selected for the brine dispersion scenarios, taking into consideration the following aspects:

- Exposure to ambient currents to assist in dispersion of the brine;
- Bathymetry that may cause localised high saline "hot spots";
- Distance of outfall from the desalination plant;
- Potential influence from the AWTP concentrate discharges, as predicted in the AWTP dispersion modelling;
- Proximity to environmentally sensitive areas; and
- Maritime navigation.

The 5 outfall sites considered in this study included (Figure 3):

- Gibson Island
- Fisherman's Island
- West of Mud Island;
- South of Mud Island; and
- Middle Banks

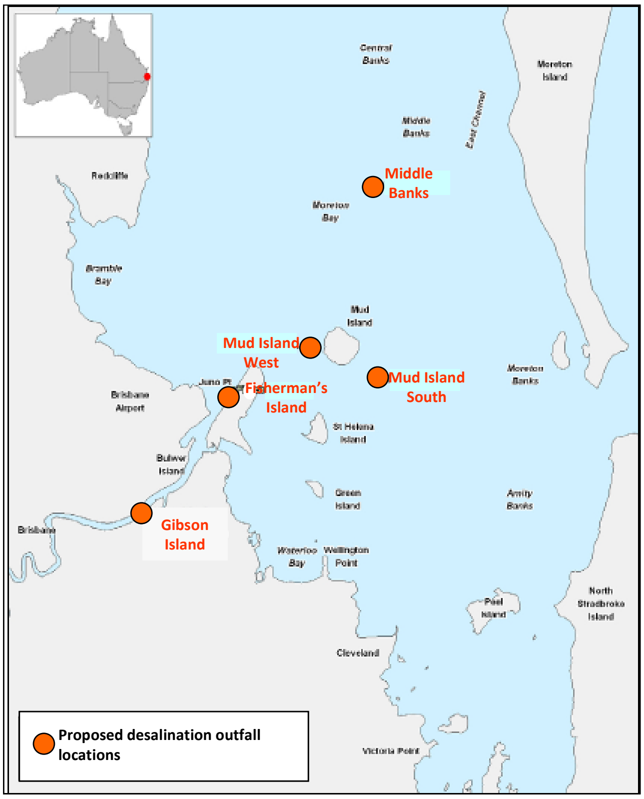

Figure 3. The five outfall sites considered in this study for possible siting of desalination plants.

The advantages and disadvantages of the different sites are presented in Table 1.

Table 1. Potential brine discharge locations in Moreton Bay.

Potential Sites	Advantage/s	Disadvantage/s
Gibson Island	• Represents an opportunity for co-location with AWTP • Has relatively minimal requirements for marine infrastructure.	• Located within the predicted influence of the AWTP concentrate discharges
Fisherman Islands	• Relatively minimal requirements for marine infrastructure • Takes advantage of deep water and currents at the river mouth in the vicinity of the navigation channel.	• Located within the predicted influence of the AWTP concentrate discharges • Proximity of many environmentally important habitats in Bramble Bay which may be influenced by the discharge.
West and South of Mud Island	• Outside the predicted influence of the AWTP concentrate discharges • Within relatively good ambient current fields, in over 10m of water depth, away from navigation channels • Relatively close to the main land.	• Proximity of some environmentally sensitive receptors on the shores of Mud Island. • The location to the south east of the island is close to a High Ecological Value (HEV) area according to the EPP (Water). • The location to the west of the island is located within the bounds of an existing spoil ground area.
Southwest of Middle Banks	• Well beyond any influence of the AWTP concentrate discharges • With good ambient currents, in over 15m of water depth, away from navigation channels and identified environmentally sensitive receptors.	• Requires construction of a marine outfall of at least 15 km in length

Five different plant capacities (100, 150, 200, 300 and 400ML/d) were simulated at each of the five outfall locations. It is assumed that such capacities correspond to brine discharges of 140, 210, 280, 420 and 550ML/d respectively.

Two additional scenarios were also modelled to evaluate the efficacy of an ebb tide strategy that could be applied to the brine discharge. Discharges under this strategy were simulated to commence one hour after high tide and to last for four hours on the ebb tide. Flow rates were calculated to deliver the same volume of brine over the four hour period as would be delivered over a full tidal cycle if the discharge was continuous. This was applied to 140ML/d and 550ML/d discharges from the Gibson Island outfall.

In addition to the above suite of scenarios, a base case scenario was also run, presenting the same conditions but without any brine discharges. The results from this scenario allowed for relative comparisons with the brine discharge scenarios. A summary of the different scenarios are presented in Table 2.

All scenarios assumed a continuous discharge of brine.

Table 2. Summary of brine discharge scenarios.

Scenario/Outfall Location	**Plant Capacity/Brine Discharge (ML/d)**				
	100/**140**	150/**210**	200/**280**	300/**420**	400/**550**
Base Case (no discharge)	N/A	N/A	N/A	N/A	N/A
Gibson Island	✓	✓	✓	✓	✓
Gibson Island (Ebb Tide)	✓	x	x	x	✓
Fisherman's Island	✓	✓	✓	✓	✓
Mud Island (West)	✓	✓	✓	✓	✓
Mud Island (Southeast)	✓	✓	✓	✓	✓
Middle Banks (Southwest)	✓	✓	✓	✓	✓

5 Summary of Results and Interpretation

Results of brine dispersion modelling were interpreted using the risk assessment approach:

***Risk** = **Exposure** to salinity changes x **Effects** of salinity on the ecological values*

5.1 Effects of Salinity on the Ecological Values of Moreton Bay

This literature review provided an overview of possible ecological receptors in Moreton Bay, and a preliminary assessment of the sensitivities of these receptors to increased salinities. The specific objectives of this literature review were to:

- identify key ecological values of the study area;
- determine expected salinity tolerance limits of sensitive ecological vectors, focussing on species, communities and habitats of high ecological value; and
- identify knowledge gaps in terms of potential ecological impacts, providing prioritised recommendations for further research to address these gaps.

5.1.1 Direct Salinity Effects on Species

The review of literature indicates that mortality of many marine flora and fauna species can occur at salinity concentrations exceeding 40g/L, with seagrass species particularly sensitive to increases above this limit. However, physiological functions (e.g. reproduction, growth etc.) of many species can be impaired at far lower salinity concentrations than this. ***Therefore, adopting a conservative approach,***

salinity concentrations of approximately 2-5g/L above background maximum salinity concentrations (average of 35 g/L) could result in chronic and possible adverse effects on more sensitive species.

Ecological impacts will vary with the site, the size and design of the desalination plant, and the ecology and hydrodynamics of the receiving water body (Hopner and Windelberg 1996, Hopner and Latterman 2002). Hopner and Windelberg (1996) argued that ***ecosystems such as mangroves, coral reefs and sea grass meadows are among the regions most sensitive to desalination discharges.***

Salinity Effects on the Ecological Values of Moreton Bay

There is little information about how the magnitude, frequency and duration of elevated salinity affect Australian coastal ecosystems (Khan et al. 2008, QWC 2008). Only few studies have addressed the impact of brine plumes on benthic communities, which is difficult to assess due to the spatial and temporal variability of these systems (Raventos et al. 2006).

Due to the sensitivity of marine biota to changes in environmental conditions, it is likely that adverse impacts will be observed should biota in Moreton Bay be subjected to hypersaline conditions (i.e. salinity greater than background maximum seawater concentrations). The intensity of these impacts will vary for different species, and will also depend on the characteristics of the discharge plume. Very limited data regarding quantified salinity tolerance limits are available for biota, both within the study area and on a wider scale. Salinity tolerances of key species groups and other ecological features known or likely to occur in the areas adjacent to the proposed locations of brine discharges in Moreton Bay were determined based on literature review. A summary is presented in Table 3.

Table 3. Salinity tolerance of key taxa present in Moreton Bay (based on literature review).

Group	Salinity Sensitivity
Phytoplankton	• Highly species specific. • Many spp. intolerant of 'hypersaline' conditions (i.e. salinity > background) • Salinity > 2g/L above background may represent risk to sensitive species
Mangroves	• Salinities of 40 to 50g/L likely to have mortality • Optimal growth of seedlings ~5 to 30g/L. • Salinities > background likely to negatively effect seedling growth & possibly other functions
Saltmarsh	• Optimal growth is species specific, but typically less than ambient seawater • Salinities > maximum background likely to negatively effect growth & possibly other functions
Seagrass	• *Halophila ovalis* intolerant of salinity > 45g/L, *Zostera* intolerant of salinity >70g/L. • Chronic effects & tolerances of local species unknown. • Optimal growth range of most species = 30 – 40g/L, hence salinity > 2-5g/L background may represent risk.
Corals	• Salinity >40g/L result in physiological impacts to corals • Salinities > 2-5g/L maximum background likely to negatively effect physiological functions of some spp.
Benthic infauna	• Highly species specific. • Many species intolerant of 'hypersaline' conditions (i.e. salinity >background) • Salinity > 2g/L above background may represent risk to sensitive species
Oysters (aquaculture)	• Rock oyster max salinity ~36g/L • Pearl oyster max. salinity unknown, likely to be close to maximum seawater
Fish	• Larvae and eggs may be sensitive to salinities > background • Adults thought to be less sensitive to salt
Marine megafauna	• Dugongs observed at 40 to 70g/L • Dugong food resources (seagrass) more sensitive to elevated salinity (see seagrass) • Salinity sensitivity of sea turtles unknown

5.1.2 Stratification and Dissolved Oxygen Depletion

Discharge of brine plume has the potential to deplete dissolved oxygen (DO) in receiving waters, via two mechanisms:

- *Vertical density stratification* within the water column, driven by the salinity difference between the brine plume and the receiving waters. The stratification isolates bottom waters from replenishment by atmospheric oxygen, which means that DO consumed by bacterial respiration can lead to hypoxic or anoxic conditions at the sediment/water interface (WA EPA 2004, Hodges et al. 2009, Khan et al. 2008).

- *Decrease in the solubility of oxygen* in water as salinity increases (Sherwood et al. 1991).

The first of these two mechanisms is of greatest concern because it can lead to very low levels of DO, which have serious ecological consequences (Diaz 2001). Anoxia at the sediment-water interface can also contribute to other water quality problems by triggering the release of nutrients and metals from the sediments (Song and Müller 1999). The two mechanisms interact however, because density stratification inhibits mixing, leading to higher salinity in bottom waters, and hence lower oxygen solubility.

Brine plumes may have little impact on the far-field salinity, but layers of high density water may form above the sediments. Fernandez-Torquemada et al. (2005) found that while only minor changes in salinity were observed at the surface of the receiving water body adjacent to a desalination plant in Spain, a thin salinity plume at the bottom of the water column extended a number of kilometers from the discharge point.

Low oxygen concentrations resulting in hypoxia (dissolved oxygen <2 mg/L) in the water column may affect a number of coastal/estuarine ecosystem components. ***Hypoxia has been linked to mortality of benthic vegetation such as seagrass, benthic macroinvertebrates, and can lead to changes to benthic bacteria communities and sediment nutrient dynamics.*** More mobile organisms such as fish and prawns can evade hypoxic waters, but may be indirectly affected by changes in prey resources and physio-chemical habitat conditions.

In terms of the effects of hypoxia from stratification, it is not possible to provide an assessment of the relative risk of each of the various outfall proposals at this stage, as the level of risk (likelihood/magnitude of impact) will depend on local environmental conditions at the outfall site and surrounds, as well as the design of the outfall diffuser and physio-chemical properties of the effluent. Further information on the local hydraulics and mixing characteristics of each outfall site is required to undertake such an assessment.

5.2 Exposure to Salinity Changes

Potential impacts of brine discharges were assessed at sensitive/high conservation value ecological receptor sites located throughout the study area, as well as at the outfall location for each site. Receptor sites included declared conservation zones (RAMSAR wetland sites, HEV areas, Fish Habitat Areas, Non-General Use Zones within Moreton Bay Marine Park), and high values habitats and constituent flora and fauna. The locations of these receptors are shown in Figure 4. Further details on these sites are included in Appendix B of the ARUP Final Report. The impact assessment was principally based on maximum elevations of salinity above background concentrations and is therefore conservative (peak salinity concentrations may only occur for short duration at times of slack water; e.g. less than half an hour of either side of high or low water).

In the absence of any relevant guidelines or applicable water quality objectives, the following impact categories were adopted in this assessment to compare the potential risk of ecological impacts for each discharge scenario:

- ***Negligible risk*** – salinity <1g/L above background concentrations. No major changes to biota expected;
- ***Low risk*** – salinity 1 to 2g/L above background concentrations. Possible minor physiological impacts to sensitive species or life-cycle stages although mortality not expected;
- ***Moderate risk*** – salinity 2 to 5g/L above background maximum concentrations. Physiological impacts to a wide range of species possible, mortality of sensitive species also possible;
- ***High risk*** – salinity >5g/L above background maximum concentrations. Mortality and physiological impairment highly likely for many species.

A summary of the relative risk of impacts for each scenario is provided in Table 5.

The impact assessment did not take into consideration options for dimensions of initial mixing zones. However, the concentrations set for *"negligible and low risk categories"* in this project are comparable to ecologically-acceptable salinities set for the Gold Coast (Tugun) Desalination facility and other interstate plants in Australia (Table 4).

Table 4. Examples of dimensions of mixing zones and salinity targets set outside such mixing zones in other desalination plants in Australia.

Site	Minimum dimension of initial mixing zone	Salinity change target outside initial mixing zone	Commentss
	m	g/L	
Gold Coast (Tugun) Desalination Facility	120	2	EPA licence
Perth Seawater Desalination Plant	50	1	Basis of diffuser design
Wonthaggi Desalination Plant	500	1	Assessment of EES

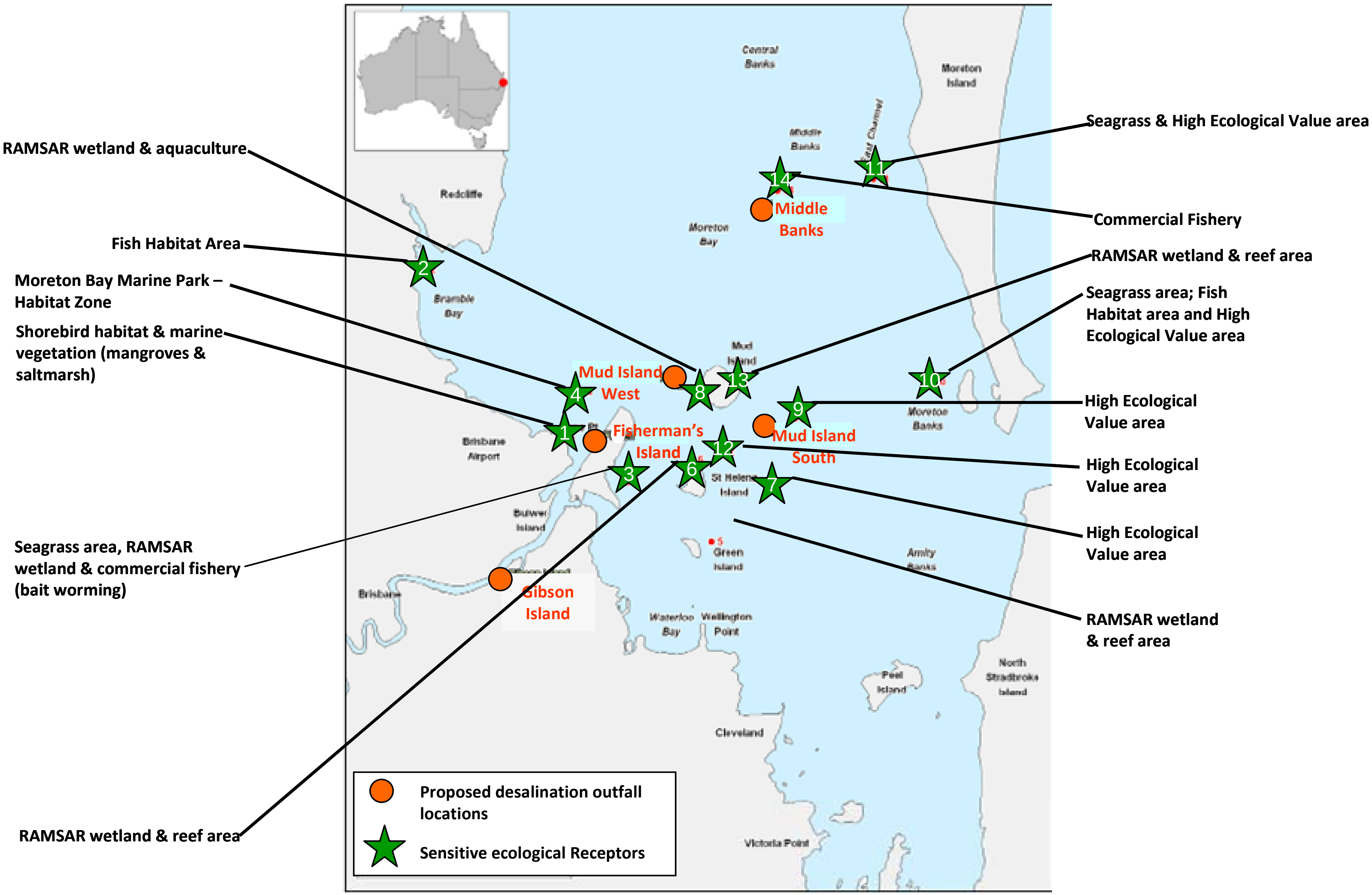

Figure 4. Location of ecologically sensitive receptor sites in Moreton Bay relative to the proposed potential brine discharge locations.

Table 5. Summary of relative risks of different discharge scenarios on different locations (discharge point, Receptor Sites 1 and 4).

Locations		Gibson Island			Fisherman's Island			Mud Island (South)	Mud Island (West)	Middle Banks (Southwest)
		Discharge Point	*Receptor Site 1*	*Receptor Site 4*	*Discharge Point*	*Receptor Site 1*	*Receptor Site 4*	*Discharge Point*	*Discharge Point*	*Discharge Point*
Brine Discharge (ML/d)	140	[orange]	[cyan]	[cyan]	[yellow]	[light blue]	[light blue]	[yellow]	[light blue]	n.i.
	210	[orange]	[yellow]	[cyan]	[orange]	[light blue]	[light blue]	[yellow]	[yellow]	[yellow]
	280	[orange]	[yellow]	[cyan]	[orange]	[light blue]	[light blue]	[orange]	[yellow]	[yellow]
	420	[red]	[orange]	[yellow]	[red]	[yellow]	[light blue]	[orange]	[orange]	[orange]
	550	[red]	[orange]	[yellow]	[red]	[yellow]	[yellow]	[orange]	[orange]	[orange]

[red] - ***High Risk*** : salinity >5g/L above background maximum conditions. Mortality and physiolocial impairment highly likely for many species

[orange] - ***Moderate Risk*** : salinity 2 to 5g/L above background maximum conditions. Physiological impacts to a wide range of species possible; mortality of

[yellow] - ***Low Risk*** : salinity 1 to 2g/L above background maximum conditions. Possible minor physiological imapts to sensitive species or life cycle stages

[light blue] - ***Negligible Risk*** : salinity < 1g/L above background maximum conditions. No major changes to biotia expected.

n.i. - *No impacts observed*

6 Recommendations

6.1 Siting of Desalination Plants in Moreton Bay

Desalination of seawater is an increasingly important source of potable water worldwide (Hopner and Windelberg 1996, Hopner and Latterman 2002, Raventos et al. 2006, Gacia et al. 2007, Khan et al. 2008). One of the major environmental issues associated with desalination plants is the appropriate disposal of the brine or concentrate stream.

As well as costs (which are not addressed in this study), the optimal location of brine discharges should take into consideration the following:

- Occurrence of confounding stresses on the receiving waters and associated ecological communities (e.g. AWTP concentrates/plumes); and
- Proximity to high ecological value areas, which need to be protected.

Discharge Sites

Of all the sites, the Middle Banks site will have the least risk because of the relatively high exchange rates due to tidal flushing and currents. While no impacts were predicted on adjacent receptor sites (11 and 14), Middle Banks is located in close proximity to one of the most pristine areas in the Bay, supporting healthy seagrass, dugongs and turtle populations. Apart from the higher costs of constructing a marine outfall if brine were to be discharged in this area, it is important to ensure that the high ecological value of this site is protected.

Of the three western sites, siting a discharge at Gibson Island is not recommended. This site is the highest risk option at all plant capacities in terms of the impact in the vicinity of the discharge point. There is also a material risk of discharge impacts on the Bramble Bay area and upstream of the river mouth (see Figure 5), both of which are likely to be under stress with potential AWTP concentrate discharges.

Modelling indicated that Mud Island is the lowest risk of the potential sites. Mud Island site is outside the predicted influence of the AWTP concentrate discharges, within relatively good ambient current fields, in over 10m of water depth, away from navigation channels and relatively close to the mainland. However, the potential discharge location south of the island is close to a High Ecological Value (HEV) area. Hence, this site has a slightly higher risk than the western side which is an existing spoil ground area.

Discharge Rates/Plant Capacities

The highest discharge rate of 550 ML/day resulted in moderate to high risks at all of the five potential desalination sites. The smallest plant capacity of 140 ML/day poses negligible to no risks at the discharge sites and receptor areas in Fisherman's Island and Mud Island sites.

Summary

The preferred desalination plant discharge site is Mud Island West, with plant capacities of up to 280 ML/day having negligible to low risks. A discharge site in Gibson Island is the most risky option, but there is potential for lower discharge site (140 ML/d) to be sited in Fisherman's Island. The key impact of increased salinity in the vicinity of the discharge site is the key constraint to the development of larger desalination facilities. These risks may be reduced through detailed design or through the use of a combination of plant capacities and locations, small discharge in Fisherman's Island with a larger discharge west of Mud Island.

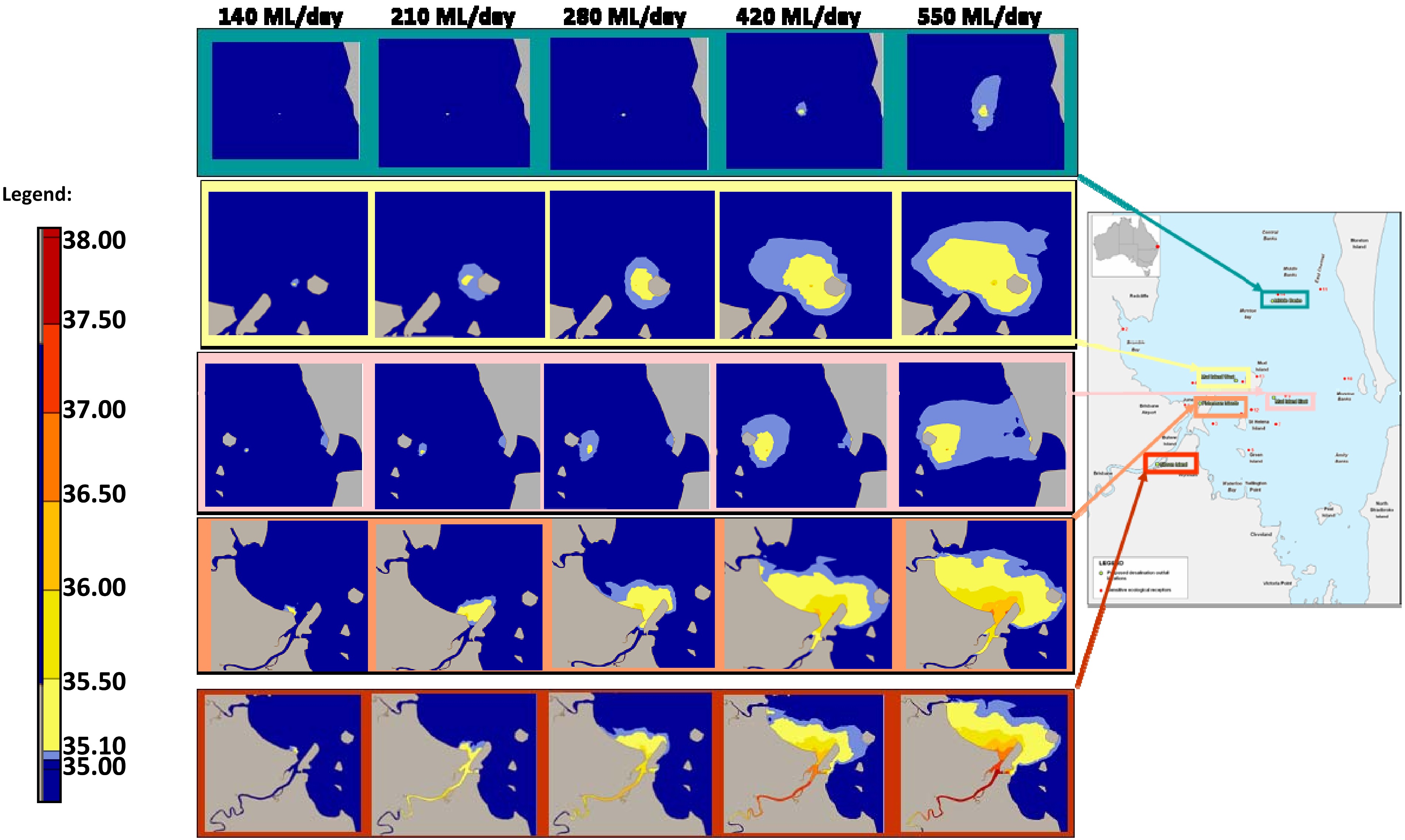

Figure 5. Summary of exposure of different areas of Moreton Bay to the scenarios for siting of desalination plants.

6.2 Implementing a Robust Risk-Assessment Approach

Recommendations are made based on the risk-assessment approach whereby the risks of the different desalination plant siting scenarios were determined based on the exposure of Moreton Bay to salinity changes and the effects of salinity on the specific ecological values of Moreton Bay. It is strongly recommended that future work include more detailed environmental impact assessments of proposed locations, with the aim of using the risk assessment approach in a more quantitative manner.

6.3 Recognising Limitations of this Study and Addressing Knowledge Gaps

The methodology, specifically the current Moreton Bay Receiving Water Quality Model (RWQM) model, used in this study is sufficient to address the objectives set by QWC. This study has provided information which could be used to determine the potential sustainable capacity of a desalination plant at the Lytton site. However, it is crucial that limitations of the study need to be considered and addressed in a future phase (Phase 3). These limitations are outlined below, together with the recommended response:

- The modelling undertaken has been of a 2D, depth averaged, nature and has therefore not simulated the transport of negatively buoyant brine through the water column. ***A potential to underestimate impacts resulting from denser saline waters occurring near the seabed is apparent, particularly in the region of the outfall.*** It is noted that desalination brine, being denser than the surrounding waters, may 'flow' and accumulate in a somewhat different manner to that predicted by the existing Brisbane River and Moreton Bay Receiving Water Quality Model (RWQM), which cannot allow for density driven currents.

  Recommendation: Future studies should include 3D advection-dispersion modelling of the proposed outfall sites. This modelling recommendation has been incorporated into the scope of version 3 of the SEQ RWQM, to be developed by the SEQ Healthy Waterways Partnership. Version 3 will be developed in 2009-2010.

- ***The study only included far field modelling***, making it difficult to assess the potential for poor initial mixing of the negatively buoyant brine. How a multi-port diffuser may assist in dilution of the brine has also not been assessed.

  Recommendation: Based on national and international best practice, near-field modelling is considered a vital part of a numerical modelling exercise in attempting to understand the impact of discharges from desalination plants. Near-field modelling should be undertaken to determine the initial dilution zone of the negatively buoyant brine plume and how a multi-port diffuser may assist in dilution of the brine. As above, provisions for the SEQ Receiving Water Quality Model Version *3* platform to accommodate such modelling activity have been included in the scope of work for 2009-2010.

- ***The scope of this study includes only ecological impacts from ambient salinity conditions.***

  Recommendation: An assessment of impacts that may exist due to other potential contaminants within the discharge streams needs to be undertaken. Phase 3 should include detailed bioassays of other potential contaminants of discharge streams using key ecological species in Moreton Bay.

- ***The literature review conducted has identified the lack of detailed information on salinity tolerances and impacts on species occurring in Moreton Bay.*** In the absence of this data, the results of the present study should be considered as indicative only, and should only be used for comparing the potential significance of impacts among discharge sites and at different discharge scenarios.

  Recommendation: Further investigation on the following is required:

  - Key dispersal and migratory pathways of marine organisms within the Bay;
  - Key spawning sites for fish species that may be affected by brine discharges;
  - The effect of elevated salinity on key biogeochemical (e.g. sediment nutrient- carbon flux) and biological processes (reproduction, recruitment etc.); and
  - Patterns (in space and time) in benthic in-fauna community structure on a Bay-wide scale, and areas of particular biodiversity value.

- ***Almost all existing information on salinity tolerances in the literature review tend to focus on acute and chronic responses of biota to different salinity concentrations over a pre-determined time*** (~24 to 96 hours is typical for eco-toxicological experiments).

  Recommendation: Further investigation on the frequency and duration of exposure and rate of change needs to be conducted.

- ***It is also considered that already stressed ecosystems subjected to other external pressures that are present in some areas of Moreton Bay may exhibit less resilience to elevated salinity conditions.*** **Similarly, sites impacted by elevated salinity conditions may become less resilient to other pressures that may arise.**

  Recommendation: Phase 3 investigations should be linked to the study of overall resilience of Moreton Bay. A current Australian Research Council (ARC Linkage) grant to the University of Queensland and Griffith University, in partnership with the SEQ Healthy Waterways Partnership and Qld Environmental Protection Agency, aims to understand the resilience of Moreton Bay to climate change. The project would determine nutrient and sediment budgets for the Bay. Such an initiative could be expanded to address resilience of Moreton Bay ecological communities to salinity variations.

6.4 Overview of Phase 3 Objectives and Design

Based on the limitations of this study, a proposed design and opportunities for Phase 3 is presented in Table 6.

Table 6. Objectives, design and opportunities for Phase 3.

Objectives	Proposed Methods	Opportunities
Address impacts of brine discharge on stratification and oxygen depletion in the benthic zone	• 3D advection-dispersion modelling of all the proposed outfall sites • Detailed mapping of ecological communities in the vicinity of outfall sites and bioassays to determine DO depletion effects	SEQ HWP is currently developing the version 3 of the Moreton Bay Receiving Water Quality Model (RWQM). A 3D platform is one of the requirements of the ToR for the modelling consultants. Such model can be used for Phase 3.
Investigate discharge options (e.g. diffusers rather than a point source discharge)	• 3D advection-dispersion modelling of all the proposed outfall sites • Near-field and far-field modelling	As above, RWQM version 3 is being developed to allow this functionality
Address ecological impacts of potential contaminants in the brine discharge (other than just direct impact)	• Bioassays of such potential contaminants, using key ecological species in Moreton Bay	A current ARC Linkage grant to UQ, GU, EPA and HWP is aimed at understanding the resilience of Moreton Bay to climate change in relation to nutrients and sediments. Opportunities to expand the existing project to address salinity effects
Investigate effects of frequency and duration of exposure to salinity and rate of change	• Bioassays and modelling (see above)	See above
Investigate cumulative effects of other stressors (e.g. nutrients, sediments, etc.)	• Bioassays and modelling (see above)	See above

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